Curriculum Council

TERTIARY ENTRANCE EXAMINATION, 2000

QUESTION/ANSWER BOOKLET

PHYSICS

Please place your student identification label in this box

STUDENT NUMBER - In figures

In words ____________________

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet
Physics: Formulae and Constants Sheet (inside front cover of this Question/Answer Booklet)

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler

Special Items: MATHOMAT and/or Mathaid, compass, protractor, set square and calculators satisfying the conditions set by the Curriculum Council.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.

 Ref: 444

STRUCTURE OF PAPER

Section	No. of questions	No. of questions to be attempted	No. of marks out of 200	Proportion of examination total
A: Short Answers	15	ALL	60	30%
B: Problem Solving	7	7*	100	50%
C: Comprehension and Interpretation	2	ALL	40	20%

* Note that in Section B there is some internal choice in Questions 1 and 2. For each question only one alternative should be answered. Markers will be instructed to mark only the first attempt among the alternatives (unless clearly cancelled).

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question. The value of each question (out of 200) is shown following each question.

The enclosed *Physics: Formulae and Constants Sheet* may be removed from the booklet and used as required.

Answers to questions involving calculations should be evaluated and given in decimal form. It is suggested that candidates quote all answers to three significant figures, with the exception of questions for which estimates are required. Despite an incorrect final result, credit may be obtained for method and working, providing these are clearly and legibly set out.

Questions containing specific instructions to **show working** should be answered with a complete, logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

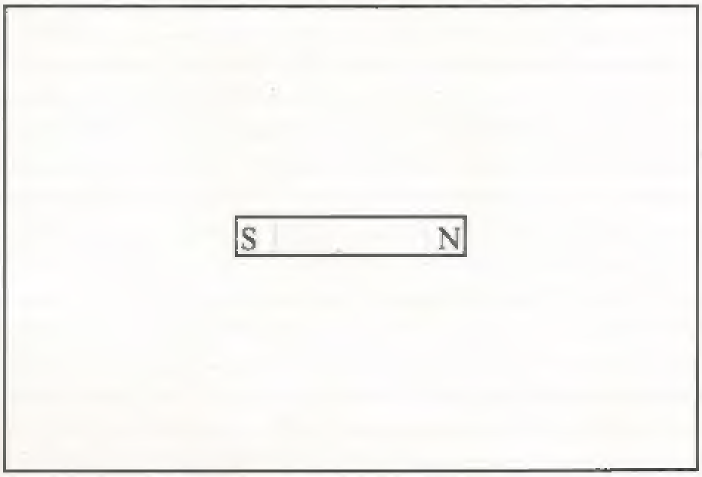
Questions containing the instruction **estimate** may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

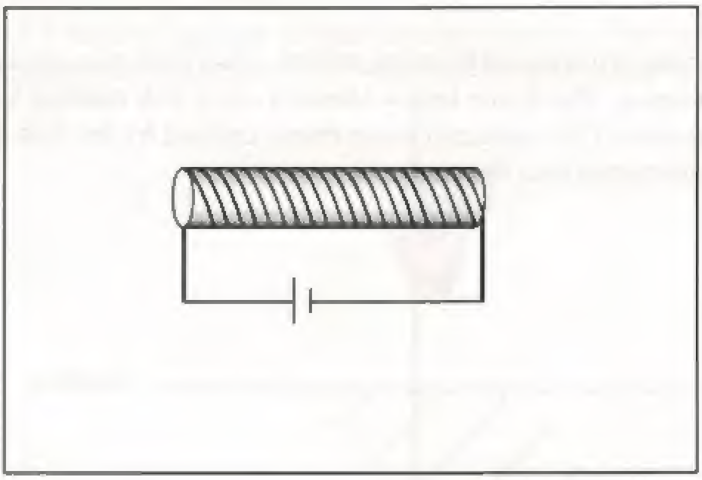
Candidates should remember that this examination is their only opportunity to show markers the depth and extent of their understanding of the aims and objectives of the subject Year 12 Physics. When descriptive answers are required, they should therefore be used to display this understanding. A descriptive answer which addresses the context of a question without displaying an understanding of Physics principles will not attract marks.

SECTION A: Short Answers **(60 Marks)**

Attempt **ALL** 15 questions in this section. Each question is worth 4 marks. Answers are to be written in the spaces provided.

1. The diagrams below represent a permanent bar magnet and a solenoid carrying a direct current. On each diagram, show the pattern and direction of the magnetic field.





2. For each of the following units, state a physical quantity that is measured by that unit. The first one has been completed to show you what is intended.

UNIT	SYMBOL	PHYSICAL QUANTITY
volt	V	Potential difference
ampere	A	
joule	J	
tesla	T	
weber	Wb	

3. An umpire blows his whistle when he is at the opposite end of the football ground from you. Estimate the time delay between the moment you see the whistle being blown and when you hear it.

4. Some fish can make croaking or grunting noises, often loud enough to be heard from a considerable distance. The figure below shows a noisy fish making sounds under water. Sketch the behaviour of the refracted wave fronts emitted by the fish after they have been refracted and transmitted into the air.

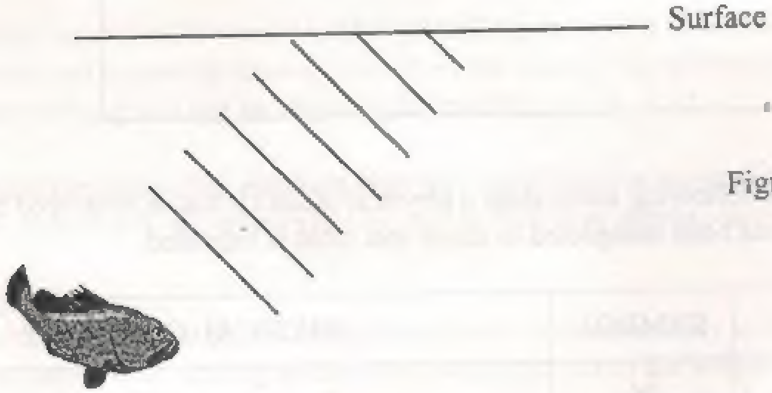
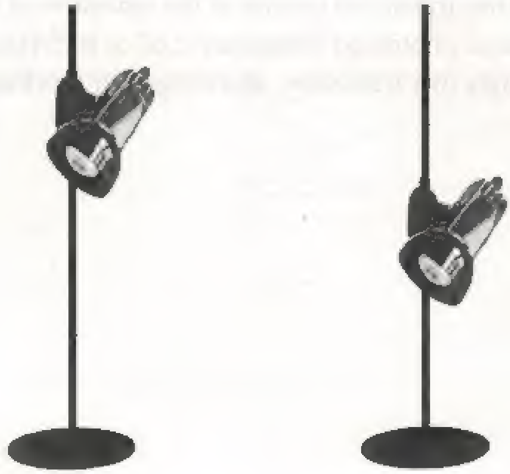


Figure 1

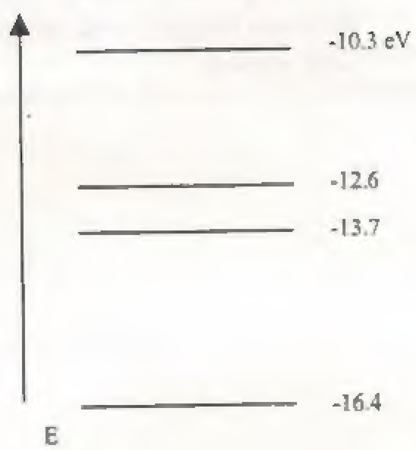
5. The Karri Creek Netball Club has some very enthusiastic supporters. When a single club supporter shouts, the sound intensity level 10 m away is 75 dB. What would the sound intensity level be if all twelve of the Club's supporters shouted together, 10 m away from you?

6. The height of a reading light on its stand can be adjusted. The light is shown at two different heights in the diagrams. For which of these positions is it more stable. Justify your answer.



7. Give an example of forced oscillations from a context you have studied. State what causes the oscillations in your example.

8. Some of the energy levels of the element australium are shown in the diagram. One electron transition results in the emission of an infrared photon of frequency 2.65×10^{14} Hz. Identify this transition, showing your working.

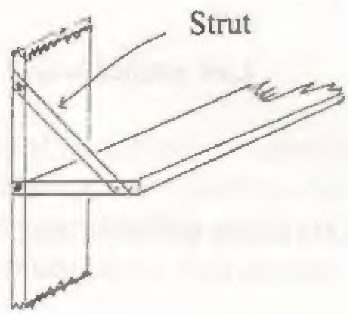


9. On a stress-strain diagram, sketch the graphs you would expect to measure for a brittle and a ductile material. Label each line.

Classify glass as either brittle or ductile.

Answer: ______________________

10. A storage shelf has a strut at each end. What is the most important reason for this strut? Briefly explain the physical principle.



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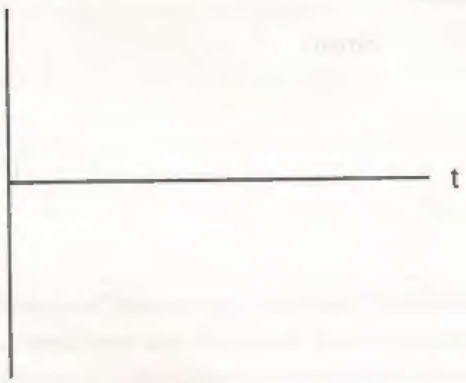
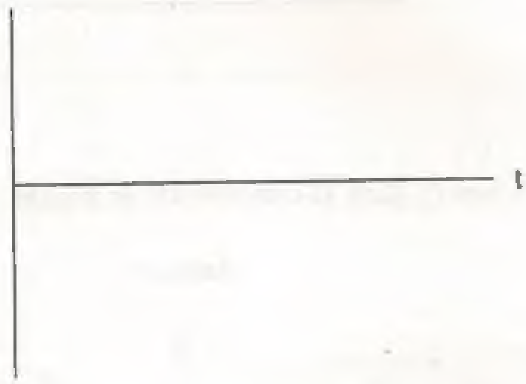
11. What is meant by the term *displacement* as applied to a sound wave?

Sketch graphs of displacement versus time for a low pitched sound and a high pitched sound.



Low pitched sound



High pitched sound

12. Do sound waves diffract. If you wanted to try and demonstrate that your answer is correct, how would you try to do this? Include a diagram in your explanation.

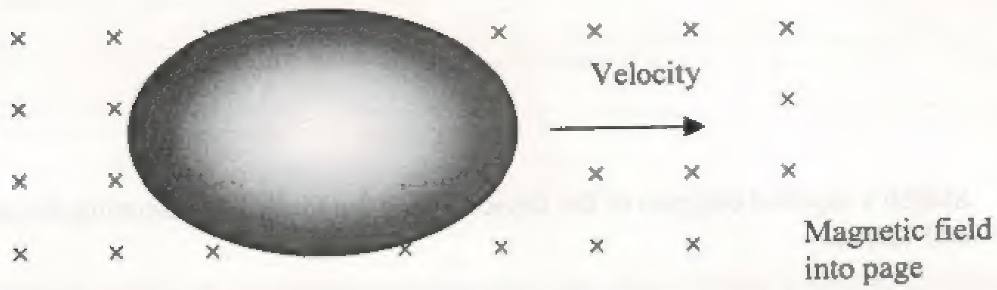
13. My portable stereo runs on 9.0 V, but I can connect it safely to the 250 V mains through a power cord with a "black box" in it.

(a) What is the black box called?

(b) Sketch a labelled diagram of the device inside the black box, showing the input and output.

14. The picture on your TV set is generated by electrons fired at the screen at a speed of 1.2×10^7 m s^{-1}. Calculate the magnitude of the force exerted on these electrons by the earth's magnetic field, which is 55 μT, when the electrons are travelling at right angles to the field.

15. An egg-shaped iron meteorite is 40 mm long and 25 mm wide. It travels at right angles to the earth's magnetic field, as shown below.



(a) Show, on the figure above, which part of the meteorite will be negatively charged as a result of the emf induced by its motion through the field.

(b) Calculate the size of the emf induced in the meteorite when it is moving at 30 km s^{-1} and the magnetic field intensity is 30 μT.

SECTION B: Problem Solving **(100 Marks)**

Attempt **ALL** 7 questions in this section.

Note that some questions have alternatives. Follow the directions in these questions with care.

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1. [Total 12 marks]

While on vacation, Brigette visited a European castle. It was a windy day, and she could hear a sound coming from the fireplace. She concluded that the wind was generating a standing wave of frequency 30 Hz in the chimney, which was acting as a pipe open at both ends.

(a) Draw labelled sketches of the fundamental and next possible harmonic of the standing wave that could exist in the chimney. Justify the shapes you have decided to draw.

[4 marks]

(b) Assuming that the sound Brigette heard was due to the fundamental standing wave, calculate the length of the chimney.

[4 marks]

Answer **ONE** question on this page [4 marks]

Either

(c) *Context: Speaking and Hearing.* Brigette has two tapes on which she could record this sound. Tape A was marked "for accurate reproduction of the human voice" while tape B was marked "accurately reproduces both high and low pitched sounds". Does it matter which tape she uses? Give a reason.

Or

(d) *Context. Musical Instruments and Reproduction.* Brigette wants to reproduce this sound on a musical instrument. She has a double bass and a violin handy. Does it matter which instrument she uses? Give a reason.

2. Answer **ONE** of the questions 2A, 2B and 2C

2A. *Context: Sunlight and starlight* [Total 12 marks]

(a) In parts of the world close to the South Pole, you can see the Southern Aurora as lights in the sky. The Aurora is caused by charged particles from the sun entering the upper atmosphere.

(i) Explain how the charged particles cause light to be emitted by the atmospheric gases. [2 marks]

(ii) What determines the colour of the light? [2 marks]

(b) Skin cancer may be caused by exposure of the skin to ultraviolet light from the Sun. Explain the process by which the ultraviolet light causes damage to the skin. Also explain why infrared radiation from the Sun is not as harmful to the skin. [4 marks]

(c) The Sun produces X-rays but these are absorbed by the earth's atmosphere. X-rays produced by medical units are not absorbed by the atmosphere between the tube and the patient. Explain this apparent contradiction. [4 marks]

2B. *Context: Medical Applications* [Total 12 marks]

(a) The He-Ne laser consists of a gas enclosed in a tube, which has a high voltage applied at its ends.

(i) Explain how the high voltage can cause the gas to emit light. [2 marks]

(ii) What determines the colour of the light? [2 marks]

(b) Gamma-rays are used in radiotherapy to treat patients with cancer. Explain the process by which the gamma-rays are able to damage the cancer cells Why are gamma-rays better at damaging cancer cells than infrared rays? [4 marks]

(c) X-rays can be used to make images of the bones within the body. Explain why the bones cause stronger X-ray shadows than the soft tissue of the body [4 marks]

2C. *Context: Domestic/Industrial Applications* [Total 12 marks]

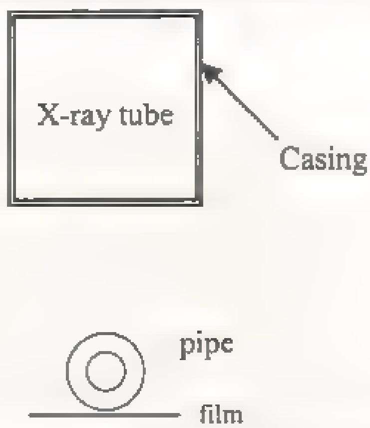
(a) Electrons fired at the screen of a colour television cause it to emit light of different colours. [2 marks]

(i) Explain how the electrons can cause light to be emitted.

(ii) What determines the colour of the light? [2 marks]

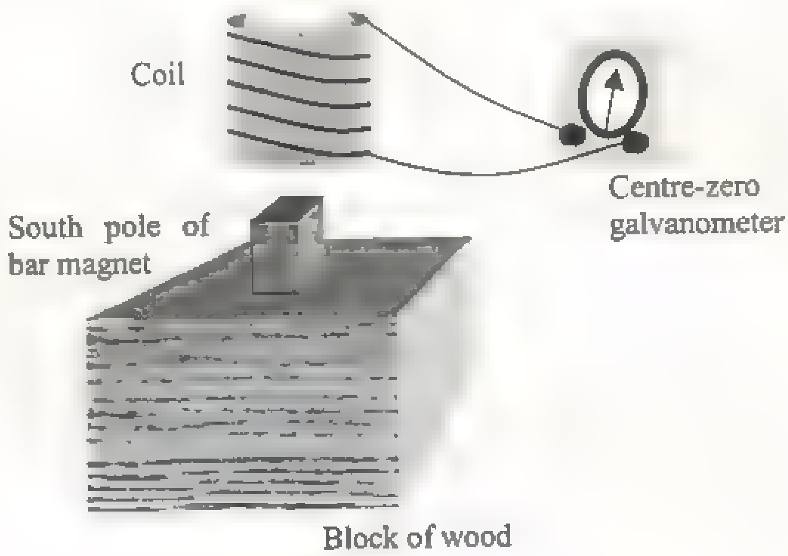
(b) Industrial X-ray machines emit infrared rays as well as intense beams of X-rays Explain the process whereby the X-rays damage cells. Why don't the infrared rays damage cells? [4 marks]

(c) The diagram shows an industrial X-ray machine taking an X-ray image of a pipe. Which parts of the casing would you make out of plastic and which from lead? Explain. [4 marks]

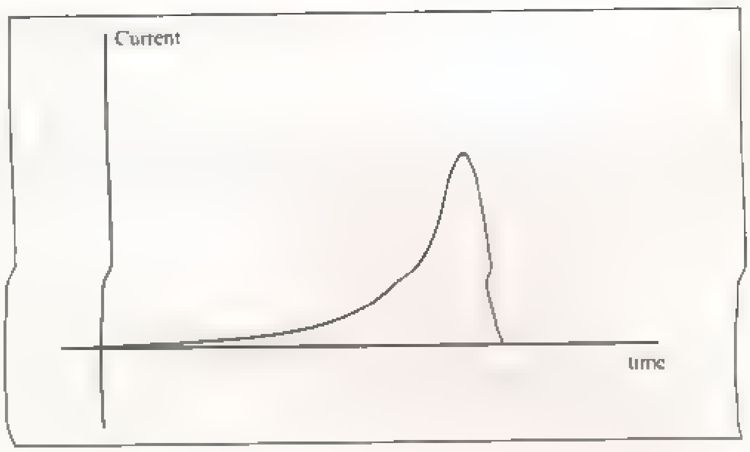


3. [Total 14 marks]

You are supplied with a large coil, consisting of many turns of insulated copper wire, whose ends are connected to a sensitive current-measuring meter (a centre-zero galvanometer). You also have a permanent bar magnet, embedded in a block of wood, so only one half (marked as the south pole) sticks out.



You move the coil down over the magnet until it rests on the block. The current varies with time as shown in the graph below.

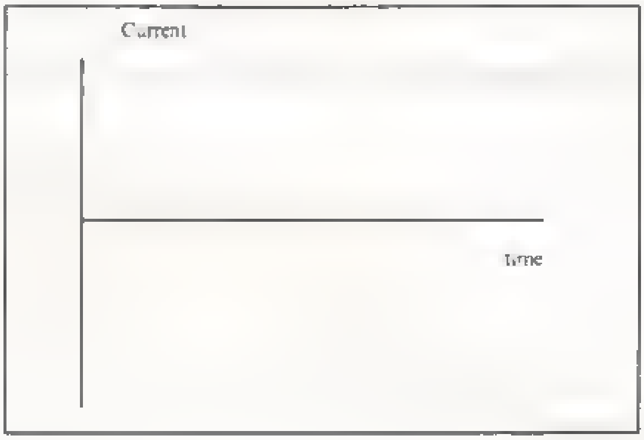


(a) Explain why the current takes the form shown in the graph. [4 marks]

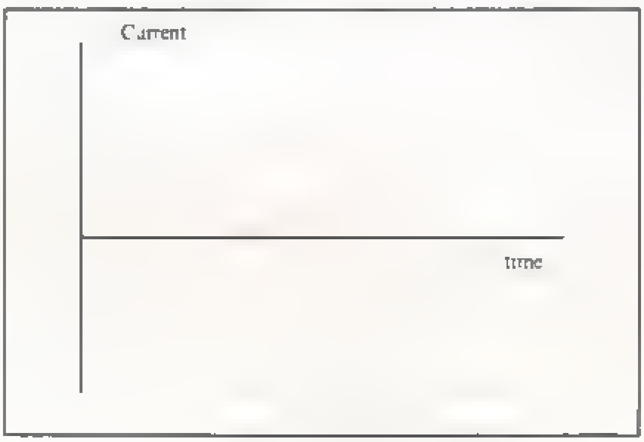
(b) You could increase the size of the current in several different ways. Describe one such way. On the graph provided earlier in this question, sketch, approximately to scale, the graph you would expect to obtain and explain why you drew it that way. [5 marks]

(c) Using the axes provided below, sketch a graph of current versus time [5 marks]

(i) When you leave the coil resting on the sheet of wood.

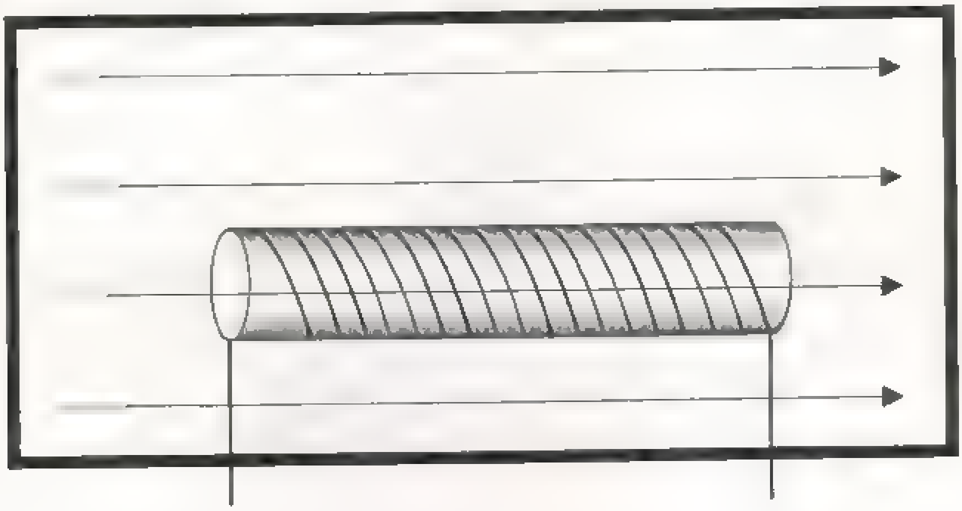


(ii) When you raise and lower the coil at a steady speed.



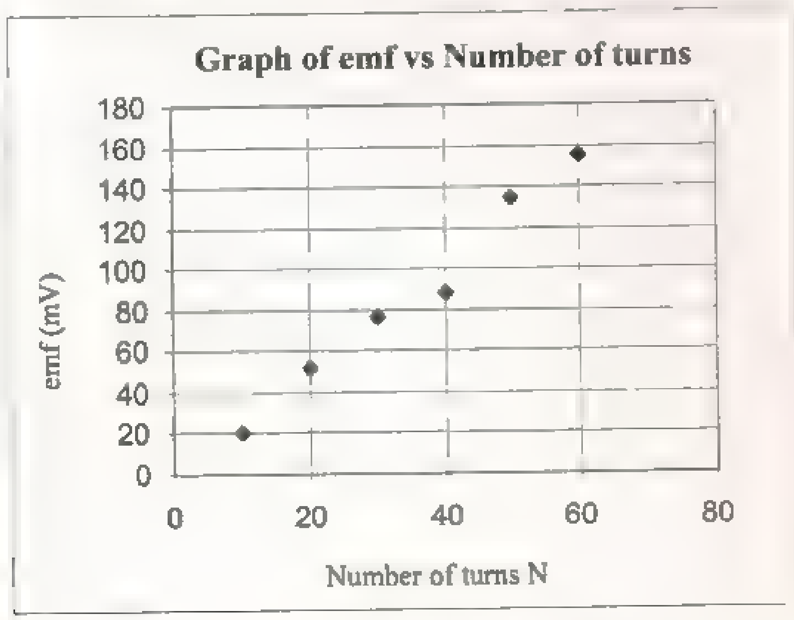
4. [12 marks total]

Henry investigated the relationship between the emf induced in a solenoid and the number of turns on it. First, he built six solenoids each made of the same insulated copper wire and consisting of circular loops 25 mm in radius.



He then placed these solenoids, one at a time, into a device that contained a uniform magnetic field of intensity 0.420 tesla, and arranged the solenoid so that the magnetic field was aligned with the long axis of the solenoid. The device had a switch that uniformly reduced the magnetic field intensity to zero over a standard time period t. The graph Henry obtained from his experiments is shown below.

(a) What equipment would Henry have to use to obtain his readings? On the partly completed diagram above, show how he would have to connect it. [2 marks]



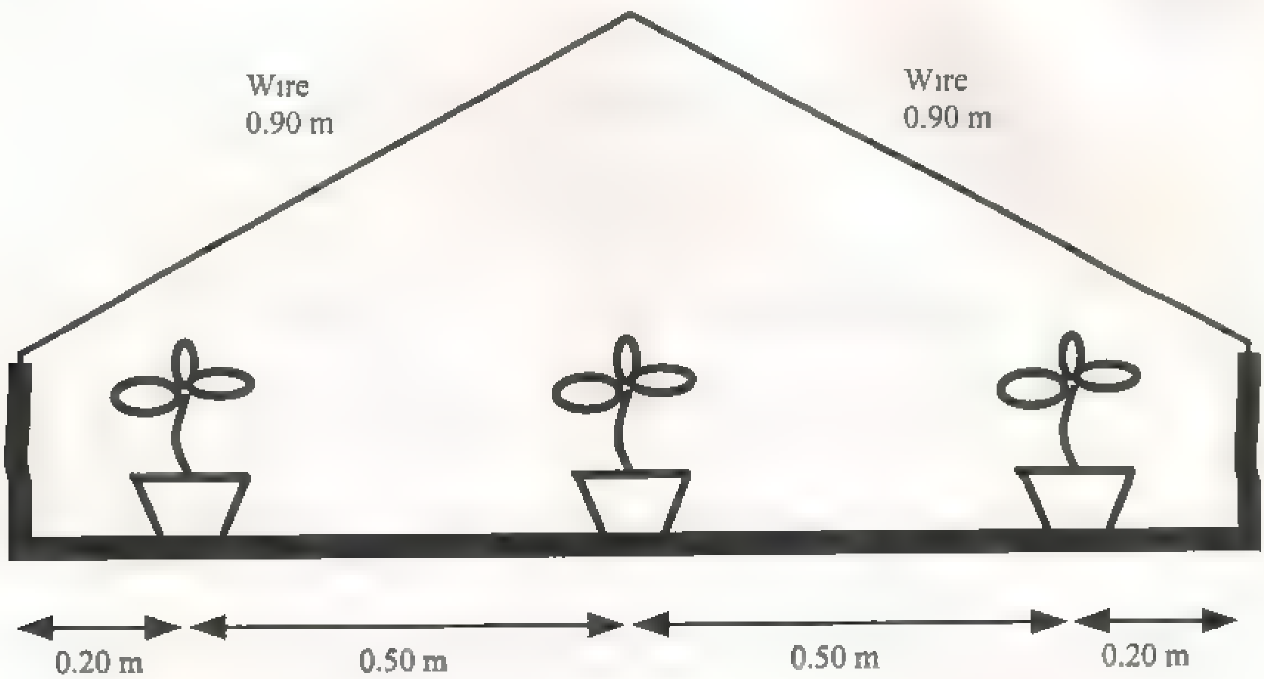
(b) Draw a line of best fit for the points shown in the graph in part (a) and determine its gradient. Include the relevant units in your answer. [4 marks]

(c) Using the gradient obtained from part (b), determine the standard time t over which Henry's device reduced its magnetic field to zero. Show your working. [6 marks]

5. [Total 18 marks]

Grandmother has some potplants on the back patio placed on a special tray held up by mild steel wires. The tray has a mass of 3.5 kg and a length of 1 4 m. The pot plants, each having a mass of 2.5 kg, are placed at the positions shown on the diagram

(a) Find the tension in each of the supporting wires, which are each 0.9 m long [6 marks]



(b) Find the minimum diameter of the wires for them not to break. Assume the wires have a circular cross section. [4 marks]

(c) Someone has told grandmother the wires will stretch when the tray and pots are hung from them. Calculate the change in length to reassure her that it will not be much. For this calculation, assume that the wires have a radius of 0.25 mm. [4 marks]

(d) Grandmother suddenly decides she wants the potplants higher, which could be done by making the wires shorter. Why would you tell her this is not a good idea? [4 marks]

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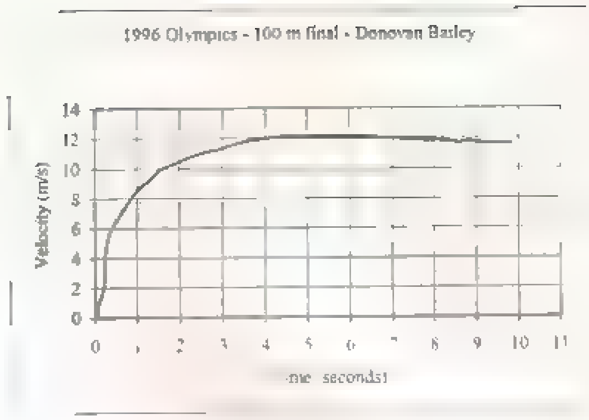
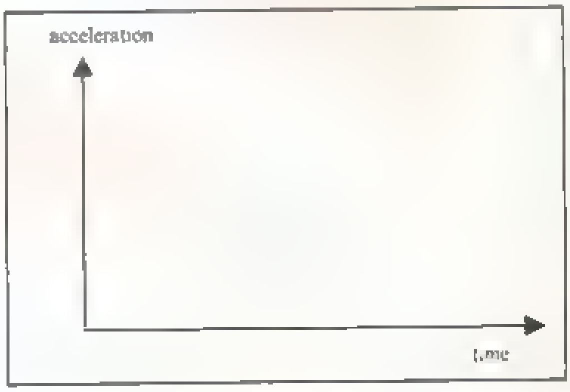
6. [Total 14 marks]

Measurements have been made of Donovan Bailey's velocity as he runs a 100 m race. These are shown in the graph on the right.



(a) Sketch a graph of acceleration versus time for the whole race (no calculations required), on the axes provided. [2 marks]



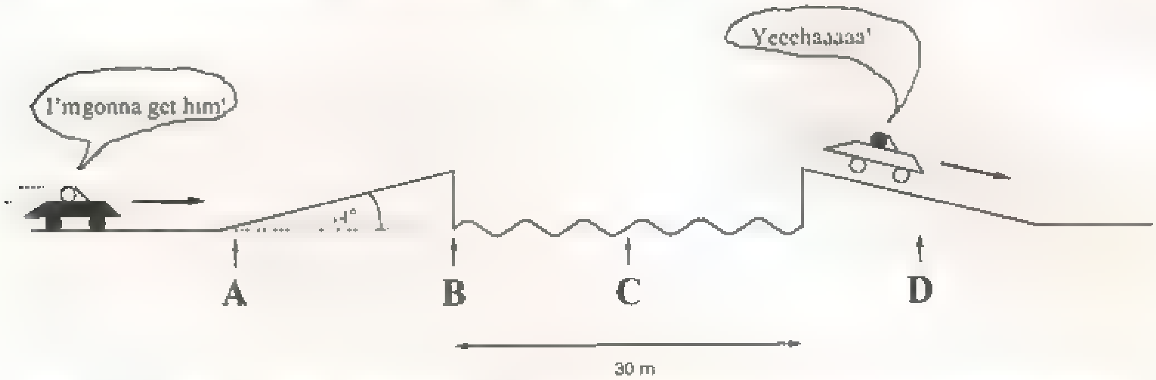
(b) Use the velocity time graph to estimate Donovan's acceleration 1 second after the start of the race. Show your working. [4 marks]

(c) Use the velocity/time graph to estimate the distance travelled by Donovan in the first 5 s of the race. [4 marks]

(d) When Cathy Freeman runs a 400 m race, she has to run in a circular path around the bend of radius 30 m. Estimate the average force she has to exert to run around this bend. [4 marks]

7. [Total 18 marks]

For the filming of a car chase scene in an action movie, two stunt drivers play the parts of the "good guy" and the "bad guy". In the movie, the bad guy is chasing the good guy. In an attempt to escape from the bad guy, the good guy drives his car at a constant high speed up the ramp of a collapsed bridge that used to span a 30 m wide river (see diagram). He successfully lands on the far ramp. A few seconds later the bad guy attempts the same trick but ends up in the river.



The stunt driver playing the bad guy is instructed to drive his car at a constant speed of 75 km h^{-1} up the ramp. The angle that the ramp makes with the horizontal is 14°.

(a) Calculate the horizontal and vertical components of the bad guy's velocity at the moment his car leaves the ramp. [4 marks]

(b) What is the velocity of the bad guy when his car is at its highest point? You must justify your answer. [3 marks]

(c) What is the acceleration of the bad guy [4 marks]

(i) just before he leaves the ramp?

(ii) just after he leaves the ramp?

(d) Suppose the good guy lands on the far ramp half way along its length at point D in the diagram. How does his speed vary during the stunt? Answer this by deleting the appropriate words below. [3 marks]

Speed at B is greater than/ equal to/ less than that at A

Speed at C is greater than/ equal to/ less than that at A

Speed at D is greater than/ equal to/ less than that at B

(e) At what minimum speed must the good guy drive in order to ensure that he clears the gap? (Assume that air resistance is negligible and give your answer in units of km h^{-1}.) [4 marks]

SECTION C: Comprehension and Interpretation **(40 Marks)**

BOTH questions should be attempted. Each question is worth 20 marks.

Read both passages carefully and answer all questions at the end of each passage. Candidates are reminded of the need for clear and concise presentation of answers. Diagrams (sketches), equations and/or numerical results should be included as appropriate.

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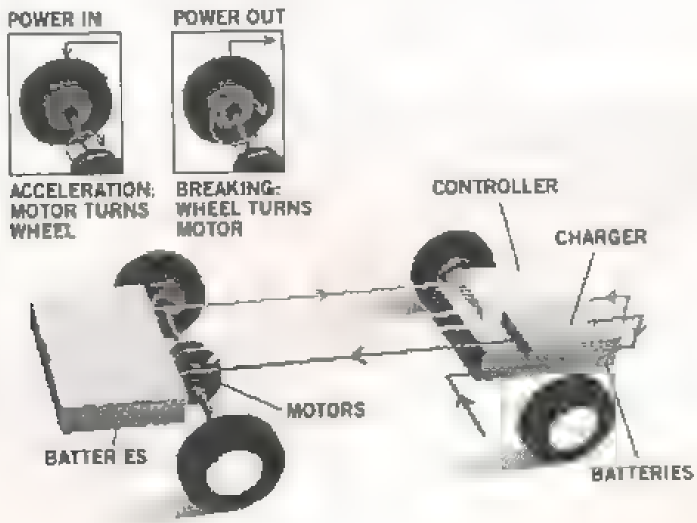
1. ELECTRIC VEHICLES

Paragraph 1

An "electric drive" vehicle may be a car powered by batteries charged with household current, or a vehicle that generates electricity on board or stores it in devices other than batteries. These motors can drive the wheels, and can extract energy from the car's motion when it slows down. Electric vehicles are more efficient and generally less polluting than conventional vehicles. The electric motor is directly connected to the wheels, so it consumes no energy when the car is at rest or coasting. This increases the efficiency by roughly one-fifth Regenerative braking schemes turn the motor into a generator when the car is slowing down. This can return as much as half an electric vehicle's kinetic energy to the storage cells, giving it a major advantage in stop-and-go city traffic.



Paragraph 2

Conventional engines convert less than 25% of the energy in a litre of petrol into the kinetic energy of the car. An electric motor converts more than 90% of the energy in its storage cells into the car's kinetic energy. The storage cells are charged by an electricity-generating system having an average efficiency of only 33%, but an electric drive still has a significant 5% net advantage over an ordinary car engine. Fuel cells, which "burn" hydrogen to generate electric current directly on board an electric car, are even more efficient.

Paragraph 3
Electric vehicles now on the market rely on lead-acid batteries, charged slowly from a standard wall plug. Lead-acid batteries are expensive, heavy and bulky, and can drive a car little more than 150 kilometres between charges. These batteries will probably become less important in future electric vehicles. Replacements being developed include ultracapacitors, which store large amounts of electricity and can charge and discharge quickly; flywheels, which store energy in a spinning rotor; and fuel cells, which convert chemical energy directly into electrical energy and emit only water vapour. Ultracapacitors owe much of their early development to the "Star Wars" ballistic-missile defense program. An ultracapacitor can store about 15 watt-hours (enough energy to run a 750 watt motor for about a minute) in a one-litre volume, and a one litre device can discharge at a rate of three kilowatts Ultracapacitors are already available in small units for calculators, watches and electric shavers.

Paragraph 4
Early electric vehicles used direct current (DC) motors. Such a motor could consist of a rectangular coil, about the size of a shoe box, made of several thousand turns of copper wire capable of carrying currents of tens of amperes for short periods without overheating. Electromagnets provide the powerful magnetic fields, up to 100 mT, required to create large torques. The current drawn by the electric motor while the vehicle accelerates is much larger than the current drawn while the vehicle cruises at constant speed. In fact, the motor draws a maximum current when it turns slowly. The faster the coil rotates, the smaller the current it carries.

(a) Explain why "turning the motor into a generator" provides regenerative braking (paragraph 1). [4 marks]

(b) The text states that "an electric drive still has a significant 5% net advantage over an ordinary car engine" (paragraph 2). Is this a reasonable statement? Use the figures supplied to justify your answer. [4 marks]

(c) My ordinary, petrol-engined car has a 75 kW petrol engine and a petrol tank with a capacity of 50 litres. If I replaced this tank with a bank of 50 one-litre ultracapacitors and installed a 75 kW electric motor, for how many minutes could the electric motor run at full power (paragraph 3)? [4 marks]

(d) Estimate the maximum torque produced by the DC electric car motor described in paragraph 4. State clearly any assumptions you make, and show your reasoning. [6 marks]

(e) Suggest one reason why not all the car's kinetic energy can be returned to the storage cells during regenerative braking (paragraph 1) [2 marks]

2. GIANT PLANETS ORBITING FARAWAY STARS

Paragraph 1

Finding planets in other solar systems (extrasolar planets) has taken a long time because detecting them from Earth, even using current technology, is extremely difficult. Unlike stars, which are fuelled by nuclear reactions, planets faintly reflect light and emit thermal infrared radiation. In our solar system, for example, the Sun outshines its planets by about one billion times in visible light and by one million times in the infrared. Because of the distant planets' faintness, astronomers have had to devise special methods to locate them. A current leading approach is the Doppler planet-detection technique, which involves analysing wobbles in a star's motion.

Paragraph 2

Here's how it works. An orbiting planet exerts a gravitational force on its host star, a force that yanks the star around in a circular or oval path, which mirrors in miniature the planet's orbit. Like two twirling dancers tugging each other in circles, the star's wobble reveals the presence of orbiting planets, even though we cannot see them directly. The trouble is that this stellar motion appears very small from a great distance. Someone gazing at our Sun from 30 light-years away would see it wobbling in a circle whose radius measures only one seventh of one millionth of one degree. In other words, the Sun's tiny, circular wobble appears only as big as a ten-cent piece viewed from 10,000 kilometres away. Yet the wobble of the star is also revealed by the Doppler effect of the starlight. As a star sways to and fro relative to Earth, its light waves become cyclically stretched, then compressed, shifting alternately toward the red and blue ends of the spectrum. From that cyclical Doppler shifting, astronomers can retrace the path of the star's wobble and, from Newton's laws of motion, compute the planet's mass, orbit and distance from its host star.

Paragraph 3

As recorded by spectrometers and analysed by computers, a star's light reveals the telltale wobble produced by its orbiting companions. For example, Jupiter, the largest planet in our solar system, is one thousandth the mass of the Sun. Therefore, every 11.8 years (the span of Jupiter's orbital period) the Sun oscillates in a circle that is one thousandth the size of Jupiter's orbit. The other eight planets also cause the Sun to wobble, albeit by smaller amounts.

Paragraph 4

Yet some uncertainty about the mass of each extrasolar planet remains. Orbital planes that astronomers view edge-on will give the true mass of the planet. But tilted orbital planes reduce the Doppler shift because of a smaller to-and-fro motion, as witnessed from Earth. This effect can make the mass appear smaller than it is. Without knowing a planet's orbital inclination, astronomers can compute only the least possible mass for the planet; the actual mass could be larger. Thus, using the Doppler technique to analyse light from about 300 stars similar to the Sun (all within 50 light-years from Earth) astronomers have turned up several planets similar in size and mass to Jupiter and Saturn. Specifically, their masses range from about a half to seven times that of Jupiter, their orbital periods span 3.3 days to three years, and their distances from their host stars extend from less than one twentieth of Earth's distance to the Sun to more than twice that distance.

(a) Scientists have to use special techniques involving the analysis of the wavelengths of light emitted from stars to detect their wobble. Why is it not possible to see the motion of the star directly by looking through a telescope? (Paragraphs 1 and 2) [4 marks]

(b) If a certain star, assumed to have a single orbiting planet, is observed to wobble backwards and forwards once every 55 days, what is the period of orbit of the planet around it? (Paragraph 3) [2 marks]

(c) Suppose there is another star with a single planet orbiting it. If the line of sight from Earth to the star is perpendicular to the plane of the planet's orbit around the star, would an astronomer using the Doppler spectral analysis technique be able to measure the star's wobble? Explain your answer. (Paragraph 4) [4 marks]

(d) The orbital radius of Jupiter is 7.78×10^{11} m. Calculate the magnitude of Jupiter's centripetal acceleration. [5 marks]

(e) The Earth also causes the Sun to wobble (paragraph 3). Calculate the size of the circle in which the Sun oscillates because of the Earth. Express your answer as a fraction of the size of the Earth's orbit. [5 marks]

END OF PAPER

ACKNOWLEDGEMENTS

SECTION C
Question 1: Article adapted from Sperling, D. (1996, November). The case for electric vehicles. *Scientific American*. Retrieved August 7, 2000 from the World Wide Web: http://www.sciam.com/1196issue/1196sperling.html

Question 2: Article adapted from Marcy, G.W. & R. Butler, R.P. (1998, March). Giant planets orbiting faraway stars. *Scientific American* [Special issue]. Retrieved August 7, 2000 from the World Wide Web: http://www.sciam.com/specialissues/0398cosmos/0398marcy.html

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